US009128611B2

(12) **United States Patent**
Gray

(10) **Patent No.: US 9,128,611 B2**
(45) **Date of Patent: *Sep. 8, 2015**

(54) **APPARATUS AND METHOD FOR INTERACTIVE DISPLAY WITH TACTILE FEEDBACK**

(75) Inventor: **R. O'Neal Gray**, Dallas, TX (US)

(73) Assignee: **TACTILE DISPLAYS, LLC**, Dallas, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **12/711,064**

(22) Filed: **Feb. 23, 2010**

(65) **Prior Publication Data**

US 2010/0149106 A1 Jun. 17, 2010

Related U.S. Application Data

(63) Continuation of application No. 12/339,721, filed on Dec. 19, 2008, now Pat. No. 8,115,745, and a continuation of application No. 12/142,624, filed on Jun. 19, 2008.

(51) **Int. Cl.**
G06F 3/0488 (2013.01)
H04M 1/725 (2006.01)

(52) **U.S. Cl.**
CPC .. ***G06F 3/04886*** (2013.01); *G06F 2203/04809* (2013.01); *H04M 1/7258* (2013.01); *H04M 2250/22* (2013.01)

(58) **Field of Classification Search**
CPC G06F 2203/04809; G06F 3/016; G06F 3/0238; G06F 1/1662; G09B 21/003
USPC 345/173–178; 715/702
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,333,160	A	7/1967	Gorski	
3,541,541	A	11/1970	Englebart	
3,641,568	A	2/1972	Brescia et al.	
3,662,105	A	5/1972	Hurst et al.	178/18
3,798,370	A	3/1974	Hurst	178/18

(Continued)

FOREIGN PATENT DOCUMENTS

CA	1243096	10/1988	340/180
DE	102 51 296	5/2004	G06F 3/023

(Continued)

OTHER PUBLICATIONS

International Search Report mailed Jan. 2, 2008, for PCT Application No. PCT/US2007/066022, filed Apr. 5, 2007, three pages.

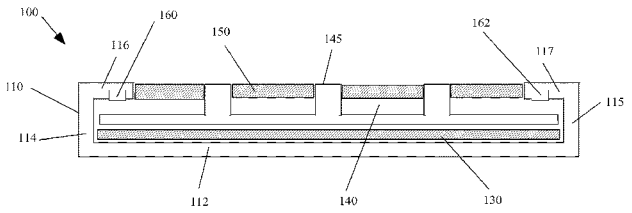
(Continued)

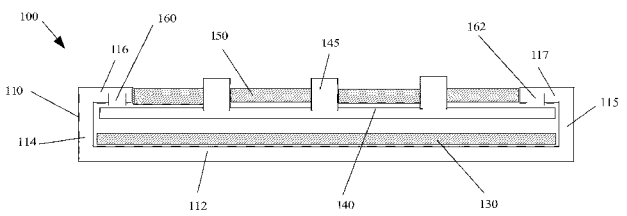
Primary Examiner — Koosha Sharifi-Tafreshi
(74) *Attorney, Agent, or Firm* — Amster, Rothstein & Ebenstein LLP

(57) **ABSTRACT**

An electronic device including an interactive display having a first mode and a second mode. The interactive display includes an image display device that displays a first user-interactive imaged keypad when the interactive display is in the first mode, and that displays a second user-interactive imaged keypad when the interactive display is in the second mode, and a substantially transparent keypad including physical keys permanently formed within the display so that the keypad provides tactile feedback to a user indicating location of keys within the first and second imaged keypads.

5 Claims, 12 Drawing Sheets





(56) **References Cited**

U.S. PATENT DOCUMENTS

3,995,126	A	11/1976	Larson	
4,127,752	A	11/1978	Lowthorp	
4,194,097	A	3/1980	Bradam	
4,246,452	A	1/1981	Chandler	200/5
4,508,942	A	4/1985	Inaba	
4,550,221	A	10/1985	Mabusth	178/18
4,654,715	A	3/1987	Feldmann et al.	
4,672,364	A	6/1987	Lucas	340/365 P
4,672,558	A	6/1987	Beckes et al.	364/518
4,692,809	A	9/1987	Beining et al.	358/247
4,695,827	A	9/1987	Beining et al.	340/365 P
4,707,570	A	11/1987	Ide et al.	
4,733,222	A	3/1988	Evans	340/365 C
4,734,685	A	3/1988	Watanabe	340/710
4,746,770	A	5/1988	McAvinney	178/18
4,771,276	A	9/1988	Parks	340/712
4,788,384	A	11/1988	Bruere-Dawson et al.	178/18
4,806,846	A	2/1989	Kerber	324/60 CD
4,898,555	A	2/1990	Sampson	445/22
4,940,346	A	7/1990	Liljenquist	
4,968,877	A	11/1990	McAvinney et al.	250/221
4,990,900	A	2/1991	Kikuchi	
5,003,519	A	3/1991	Noirjean	368/73
5,017,030	A	5/1991	Crews	400/485
5,178,477	A	1/1993	Gambaro	400/489
5,189,403	A	2/1993	Franz et al.	340/711
5,194,862	A	3/1993	Edwards	341/20
5,224,861	A	7/1993	Glass et al.	434/35
5,241,308	A	8/1993	Young	341/34
5,252,951	A	10/1993	Tannenbaum et al.	345/156
5,281,966	A	1/1994	Walsh	341/22
5,305,017	A	4/1994	Gerpheide	345/174
5,311,175	A	5/1994	Waldman	
5,345,543	A	9/1994	Capps et al.	395/137
5,376,948	A	12/1994	Roberts	345/173
5,379,057	A	1/1995	Clough et al.	
5,398,310	A	3/1995	Tchao et al.	395/144
5,412,189	A	5/1995	Cragun	
5,442,742	A	8/1995	Greyson et al.	395/146
5,463,388	A	10/1995	Boie et al.	341/33
5,463,696	A	10/1995	Beernink et al.	382/186
5,483,261	A	1/1996	Yasutake	345/173
5,488,204	A	1/1996	Mead et al.	178/18
5,495,077	A	2/1996	Miller et al.	178/18
5,513,309	A	4/1996	Meier et al.	395/155
5,523,775	A	6/1996	Capps	345/179
5,530,455	A	6/1996	Gillick et al.	345/163
5,543,590	A	8/1996	Gillespie et al.	178/18
5,543,591	A	8/1996	Gillespie et al.	178/18
5,563,632	A	10/1996	Roberts	345/173
5,563,996	A	10/1996	Tchao	395/144
5,565,658	A	10/1996	Gerpheide et al.	178/19
5,579,036	A	11/1996	Yates, IV	345/173
5,581,681	A	12/1996	Tchao et al.	395/804
5,583,946	A	12/1996	Gourdol	382/187
5,590,219	A	12/1996	Gourdol	382/202
5,592,566	A	1/1997	Pagallo et al.	382/187
5,594,810	A	1/1997	Gourdol	382/187
5,596,694	A	1/1997	Capps	395/152
5,612,719	A	3/1997	Beernink et al.	345/173
5,631,805	A	5/1997	Bonsall	361/681
5,633,955	A	5/1997	Bozinovic et al.	381/187
5,634,102	A	5/1997	Capps	395/334
5,635,958	A	6/1997	Murai et al.	
5,636,101	A	6/1997	Bonsall et al.	361/681
5,642,108	A	6/1997	Gopher et al.	341/22
5,644,657	A	7/1997	Capps et al.	382/229
5,666,113	A	9/1997	Logan	341/34
5,666,502	A	9/1997	Capps	345/352
5,666,552	A	9/1997	Greyson et al.	395/802
5,675,361	A	10/1997	Santilli	345/168
5,675,362	A	10/1997	Clough et al.	
5,677,710	A	10/1997	Thompson-Rohrlich	345/173
5,689,253	A	11/1997	Hargreaves et al.	341/22
5,710,844	A	1/1998	Capps et al.	382/317
5,729,250	A	3/1998	Bishop et al.	345/175
5,730,165	A	3/1998	Philipp	137/1
5,736,976	A	4/1998	Cheung	345/168
5,741,990	A	4/1998	Davies	84/423 R
5,745,116	A	4/1998	Pisutha-Arnond	345/358
5,745,716	A	4/1998	Tchao et al.	395/350
5,746,818	A	5/1998	Yatake	106/31.86
5,748,269	A	5/1998	Harris et al.	349/58
5,764,222	A	6/1998	Shieh	345/173
5,767,457	A	6/1998	Gerpheide et al.	178/18
5,767,842	A	6/1998	Korth	345/168
5,790,104	A	8/1998	Shieh	345/173
5,790,107	A	8/1998	Kasser et al.	345/174
5,802,516	A	9/1998	Shwarts et al.	707/6
5,808,567	A	9/1998	McCloud	341/20
5,809,267	A	9/1998	Moran et al.	395/358
5,821,690	A	10/1998	Martens et al.	313/506
5,821,930	A	10/1998	Hansen	345/340
5,823,782	A	10/1998	Marcus et al.	434/156
5,825,351	A	10/1998	Tam	345/173
5,825,352	A	10/1998	Bisset et al.	345/173
5,835,080	A	11/1998	Beeteson et al.	
5,838,138	A	11/1998	Henty	
5,854,625	A	12/1998	Frisch et al.	345/173
5,880,411	A	3/1999	Gillespie et al.	178/18.01
5,880,539	A	3/1999	Chen	
5,898,434	A	4/1999	Small et al.	345/348
5,920,309	A	7/1999	Bisset et al.	345/173
5,923,319	A	7/1999	Bishop et al.	345/175
5,933,134	A	8/1999	Shieh	345/173
5,943,044	A	8/1999	Martinelli et al.	345/174
6,002,389	A	12/1999	Kasser	345/173
6,002,808	A	12/1999	Freeman	382/288
6,020,881	A	2/2000	Naughton et al.	345/327
6,031,524	A	2/2000	Kunert	345/173
6,037,882	A	3/2000	Levy	341/20
6,050,825	A	4/2000	Nichol et al.	434/227
6,052,339	A	4/2000	Frenkel et al.	368/230
6,072,494	A	6/2000	Nguyen	345/358
6,084,576	A	7/2000	Leu et al.	345/168
6,107,997	A	8/2000	Ure	345/173
6,128,003	A	10/2000	Smith et al.	345/157
6,131,299	A	10/2000	Raab et al.	33/503
6,135,958	A	10/2000	Mikula-Curtis et al.	600/443
6,144,380	A	11/2000	Shwarts et al.	345/350
6,188,391	B1	2/2001	Seely et al.	345/173
6,198,515	B1	3/2001	Cole	348/836
6,208,329	B1	3/2001	Ballare	345/173
6,222,465	B1	4/2001	Kumar et al.	341/20
6,239,790	B1	5/2001	Martinelli et al.	345/174
6,243,071	B1	6/2001	Shwarts et al.	345/146
6,246,862	B1	6/2001	Grivas et al.	455/90
6,249,606	B1	6/2001	Kiraly et al.	382/195
6,288,707	B1	9/2001	Philipp	345/168
6,289,326	B1	9/2001	LaFleur	705/702
6,292,178	B1	9/2001	Bernstein et al.	345/173
6,323,846	B1	11/2001	Westerman et al.	345/173
6,347,290	B1	2/2002	Bartlett	702/150
6,356,259	B1	3/2002	Maeda et al.	
6,377,009	B1	4/2002	Philipp	318/468
6,380,931	B1	4/2002	Gillespie et al.	345/173
6,411,287	B1	6/2002	Scharff et al.	345/177
6,414,671	B1	7/2002	Gillespie et al.	345/157
6,421,234	B1	7/2002	Ricks et al.	361/683
6,429,846	B2	8/2002	Rosenberg et al.	
6,452,514	B1	9/2002	Philipp	341/33
6,457,355	B1	10/2002	Philipp	73/304
6,466,036	B1	10/2002	Philipp	324/678
6,497,521	B1	12/2002	Lohr	
6,515,669	B1	2/2003	Mohri	345/474
6,525,749	B1	2/2003	Moran et al.	345/863
6,535,200	B2	3/2003	Philipp	345/168
6,543,684	B1	4/2003	White et al.	234/379
6,543,947	B2	4/2003	Lee	400/489
6,570,557	B1	5/2003	Westerman et al.	345/173
6,593,916	B1	7/2003	Aroyan	345/173
6,610,936	B2	8/2003	Gillespie et al.	178/18.01
6,624,833	B1	9/2003	Kumar et al.	345/863
6,639,577	B2	10/2003	Eberhard	345/102

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,650,319	B1	11/2003	Hurst et al.	345/173
6,658,994	B1	12/2003	McMillan	99/468
6,670,894	B2	12/2003	Mehring	341/22
6,677,932	B1	1/2004	Westerman	345/173
6,677,934	B1	1/2004	Blanchard	345/173
6,706,552	B2	3/2004	Getz et al.	
6,724,366	B2	4/2004	Crawford	345/157
6,757,002	B1	6/2004	Oross et al.	345/864
6,803,906	B1	10/2004	Morrison et al.	345/173
6,822,635	B2	11/2004	Shahoian et al.	
6,842,672	B1	1/2005	Straub et al.	701/3
6,856,259	B1	2/2005	Sharp	341/5
6,888,536	B2	5/2005	Westerman et al.	345/173
6,900,795	B1	5/2005	Knight, III et al.	345/173
6,927,761	B2	8/2005	Badaye et al.	345/173
6,942,571	B1	9/2005	McAllister et al.	463/20
6,965,375	B1	11/2005	Gettemy et al.	345/173
6,972,401	B2	12/2005	Akitt et al.	250/221
6,977,666	B1	12/2005	Hedrick	345/690
6,985,801	B1	1/2006	Straub et al.	701/3
6,992,659	B2	1/2006	Gettemy	345/173
7,031,228	B2	4/2006	Born et al.	368/69
7,148,875	B2	12/2006	Rosenberg et al.	
7,339,572	B2	3/2008	Schena	
7,630,200	B1	12/2009	Eldershaw	
7,748,634	B1	7/2010	Zehr et al.	
7,978,181	B2	7/2011	Westerman	
8,115,745	B2	2/2012	Gray	
2002/0118848	A1	8/2002	Karpenstein	381/119
2002/0149570	A1	10/2002	Knowles et al.	
2003/0006974	A1	1/2003	Clough et al.	345/179
2003/0076301	A1	4/2003	Tsuk et al.	345/159
2003/0076303	A1	4/2003	Huppi	345/163
2003/0076306	A1	4/2003	Zadesky et al.	345/173
2003/0095095	A1	5/2003	Pihlaja	345/156
2003/0095096	A1	5/2003	Robbin et al.	345/156
2003/0098858	A1	5/2003	Perski et al.	345/173
2003/0190182	A1*	10/2003	Huang	400/490
2003/0206202	A1	11/2003	Moriya	345/846
2003/0234768	A1	12/2003	Rekimoto et al.	345/169
2004/0218963	A1*	11/2004	Van Diepen et al.	400/472
2004/0229663	A1	11/2004	Tosey et al.	
2004/0263481	A1	12/2004	Nishikawa et al.	
2004/0263484	A1	12/2004	Montysalo et al.	345/173
2005/0012723	A1	1/2005	Pallakoff	345/173
2005/0017947	A1	1/2005	Shahoian et al.	
2005/0052425	A1	3/2005	Zadesky et al.	345/173
2005/0052430	A1	3/2005	Shahoian et al.	
2005/0104867	A1	5/2005	Westerman et al.	345/173
2005/0110768	A1	5/2005	Marriott et al.	345/173
2005/0190159	A1*	9/2005	Skarine	345/168
2006/0022955	A1	2/2006	Kennedy	345/173
2006/0022956	A1	2/2006	Lengeling et al.	345/173
2006/0026521	A1	2/2006	Hotelling et al.	715/702
2006/0026535	A1	2/2006	Hotelling et al.	715/863
2006/0026536	A1	2/2006	Hotelling et al.	715/863
2006/0032680	A1	2/2006	Elias et al.	178/18.06
2006/0033724	A1	2/2006	Chaudhri et al.	345/173
2006/0053387	A1	3/2006	Ording	715/773
2006/0066582	A1	3/2006	Lyon et al.	345/173
2006/0085757	A1	4/2006	Andre et al.	715/771
2006/0097991	A1	5/2006	Hotelling et al.	345/173
2006/0119589	A1	6/2006	Rosenberg et al.	
2006/0181511	A1*	8/2006	Woolley	345/160
2006/0187215	A1	8/2006	Rosenberg et al.	
2006/0192771	A1	8/2006	Rosenberg et al.	
2006/0197753	A1	9/2006	Hotelling	345/173
2006/0238510	A1*	10/2006	Panotopoulos et al.	345/168
2007/0013677	A1	1/2007	Rosenberg et al.	
2007/0040815	A1	2/2007	Rosenberg et al.	
2007/0229478	A1	10/2007	Rosenberg et al.	
2008/0060856	A1	3/2008	Shahoian et al.	
2008/0062143	A1	3/2008	Shahoian et al.	
2008/0062144	A1	3/2008	Shahoian et al.	
2008/0062145	A1	3/2008	Shahoian et al.	
2008/0068348	A1	3/2008	Rosenberg et al.	
2008/0068349	A1	3/2008	Rosenberg et al.	
2008/0068350	A1	3/2008	Rosenberg et al.	
2008/0068351	A1	3/2008	Rosenberg et al.	
2008/0303796	A1*	12/2008	Fyke	345/173
2009/0046076	A1	2/2009	Bychkov et al.	
2009/0128503	A1*	5/2009	Grant et al.	345/173
2009/0315830	A1	12/2009	Westerman	
2011/0021251	A1	1/2011	Linden	
2011/0032211	A1	2/2011	Christoffersen	
2011/0141679	A1	6/2011	Dai et al.	

FOREIGN PATENT DOCUMENTS

DE	10324580	12/2004	
EP	0 288 692	7/1993	G06K 11/06
EP	0 664 504	1/1995	G06F 3/033
EP	0 464 908	9/1996	G06K 11/06
EP	0915490	5/1999	
EP	1 014 295	1/2002	G06K 11/06
GB	2009047	6/1979	
WO	97/18547	5/1997	G09G 5/00
WO	97/23738	7/1997	F16K 31/06
WO	98/14863	4/1998	G06F 3/14
WO	WO-99/38149	7/1999	
WO	03/088176	10/2003	G08C 21/00
WO	WO-2004/009488	12/2004	
WO	2006/023569	3/2006	G06F 3/044
WO	WO-2007/127585 A2	11/2007	
WO	WO-2007/127585 A3	11/2007	

OTHER PUBLICATIONS

U.S. Appl. No. 10/654,108, filed Sep. 2, 2003 entitled "Ambidextrous Mouse".

U.S. Appl. No. 10/789,676, filed Feb. 27, 2004 entitled "Shape Detecting Input Device".

"4-Wire Resistive Touchscreens" obtained from http://www.touchscreens.com/intro-touchtypes-4resistive.html generated Aug. 5, 2005.

"5-Wire Resistive Touchscreens" obtained from http://www.touchscreens.com/intro-touchtypes-resistive.html generated Aug. 5, 2005.

"A Brief Overview of Gesture Recognition" obtained from http://www.dai.ed.ac.uk/Cvonline/LOCA_COPIES/COHEN/gesture_overview.html, generated Apr. 20, 2004.

"Capacitive Touchscreens" obtained from http://www.touchscreens.com/intro-touchtypes-capacitive.html generated Aug. 5, 2005.

"Capacitive Position Sensing" obtained from http://www.synaptics.com/technology/cps.cfm generated Aug. 5, 2005.

"Comparing Tough Technologies" obtained from http://www.touchscreens.com/intro-touchtypes.html generated Oct. 10, 2004.

"GlidePoint®" obtained from http://www.cirque.com/technology/technology_gp.html generated Aug. 5, 2005.

"How do touchscreen monitors know where you're touching?" obtained from http://www.electronics.hotstuffworks.com/question716.html generated Aug. 5, 2005.

"How does a touchscreen work?" obtained from http://www.touchscreens.com/intro-anatomy.html generated Aug. 5, 2005.

"Infrared Touchscreens" obtained from http://www.touchscreens.com/intro-touchtypes-infrared.html generated Aug. 5, 2005.

"Mouse Emulation" FingerWorks obtained from http://www.fingerworks.com/gesture_guide_mouse.html generated Aug. 30, 2005.

"Mouse Gestures in Opera" obtained from http://www.opera.com/products/desktop/mouse/index.dml generated Aug. 30, 2005.

"Mouse Gestures," Optim oz, May 21, 2004.

"MultiTouch Overview" FingerWorks obtained from http://www.fingerworks.com/multoverview.html generated Aug. 30, 2005.

"Near Field Imaging Touchscreens" obtained from http://www.touchscreens.com/intro-touchtypes-nfi.html generated Aug. 5, 2005.

"PenTouch Capacitive Touchscreens" obtained from http://www.touchscreens.com/intro-touchtypes-pentouch.html generated Aug. 5, 2005.

(56) **References Cited**

OTHER PUBLICATIONS

"Surface Acoustic Wave Touchscreens" obtained from http://www.touchscreens.com/intro-touchtypes-saw.html generated Aug. 5, 2005.

"Symbol Commander" obtained from http://www.sensiva.com/symbolcomander/, generated Aug. 30, 2005.

"Tips for Typing" FingerWorks http://www.fingerworks.com/mini_typing.html generated Aug. 30, 2005.

"Touch Technologies Overview" 2001, 3M Touch Systems, Massachusetts.

"Wacom Components—Technology" obtained from http://www.wacom-components.com/english/tech.asp generated on Oct. 10, 2004.

"Watershed Algorithm" http://rsb.info.nih.gov/ij/plugins/watershed.html generated Aug. 5, 2005.

"FingerWorks—Gesture Guide—Application Switching," obtained from http://www.fingerworks.com/gesture_guide_apps.html, generated on Aug. 27, 2004, 1-pg.

"FingerWorks—Gesture Guide—Editing," obtained from http://www.fingerworks.com/gesure_guide_editing.html, generated on Aug. 27, 2004, 1-pg.

"FingerWorks—Gesture Guide—File Operations," obtained from http://www.fingerworks.com/gesture_guide_files.html, generated on Aug. 27, 2004, 1-pg.

"FingerWorks—Gesture Guide—Text Manipulation," obtained from http://www.fingerworks.com/gesture_guide_text_manip.html, generated on Aug. 27, 2004, 2-pg.

"FingerWorks—Gesture Guide—Tips and Tricks," obtained from http://www.fingerworks.com/gesture_guide_tips.html, generated Aug. 27, 2004, 2-pgs.

"FingerWorks—Gesture Guide—Web," obtained from http://www.fingerworks.com/gesture_guide_web.html, generated on Aug. 27, 2004, 1-pg.

"FingerWorks—Guide to Hand Gestures for USB Touchpads," obtained from http://www.fingerworks.com/igesture_userguide.html, generated Aug. 27, 2004, 1-pg.

"FingerWorks—iGesture—Technical Details," obtained from http://www.fingerworks.com/igesture_tech.html, generated Aug. 27, 2004, 1-pg.

"FingerWorks—The Only Touchpads with Ergonomic Full-Hand Resting and Relaxation!" obtained from http://www.fingerworks.com/resting.html, Copyright 2001, 1-pg.

"FingerWorks—Tips for Typing on the Mini," obtained from http://www.fingerworks.com/mini_typing.html, generated on Aug. 27, 2004, 2-pgs.

"iGesture Pad—the MultiFinger USB TouchPad with Whole-Hand Gestures," obtained from http://www.fingerworks.com/igesture.html, generated Aug. 27, 2004, 2-pgs.

Bier, et al., "Toolglass and Magic Lenses: The see-through interface" In James Kijiya, editor, Computer Graphics (SIGGRAPH '93 Proceedings), vol. 27, pp. 73-80, Aug. 1993.

Douglas et al., *The Ergonomics of Computer Pointing Devices* (1997).

European Search Report received in EP 1 621 989 (@ *Beyer Weaver & Thomas, LLP*) dated Mar. 27, 2006.

EVB ELEKTRONIK "TSOP6238 IR Receiver Modules for Infrared Remote Control Systems" dated Jan. 2004 1-pg.

Fisher et al., "Repetitive Motion Disorders: The Design of Optimal Rate—Rest Profiles," Human Factors, 35(2):283-304 (Jun. 1993).

Fukumoto, et al., "ActiveClick: Tactile Feedback for Touch Panels," In CHI 2001 Summary, pp. 121-122, 2001.

Fukumoto and Yoshinobu Tonomura, "Body Coupled Fingering: Wireless Wearable Keyboard," *CHI 97*, pp. 147-154 (Mar. 1997).

Hardy, "Fingerworks" Mar. 7, 2002; BBC World On Line.

Hillier and Gerald J. Lieberman, *Introduction to Operations Research* (1986).

International Search Report dated Mar. 3, 2006 (PCT/US 05/03325; 119-0052WO).

Jacob et al., "Integrality and Separability of Input Devices," *ACM Transactions on Computer-Human Interaction*, 1:3-26 (Mar. 1994).

Kinkley et al., "Touch-Sensing Input Devices," in CHI '99 Proceedings, pp. 223-230, 1999.

KIONX "KXP84 Series Summary Data Sheet" copyright 2005,dated Oct. 21, 2005, 4-pgs.

Lee et al., "A Multi-Touch Three Dimensional Touch-Sensitive Tablet," in CHI '85 Proceedings, pp. 121-128, 2000.

Lee, "A Fast Multiple-Touch-Sensitive Input Device," Master's Thesis, University of Toronto (1984).

Matsushita et al., "HoloWall: Designing a Finger, Hand, Body and Object Sensitive Wall," In Proceedings of UIST '97, Oct. 1997.

Quantum Research Group "QT510 / QWheel™ Touch Slider. IC" copyright 2004-2005, 14-pgs.

Quek, "Unencumbered Gestural Interaction," *IEEE Multimedia*, 3:36-47 (Winter 1996).

Radwin, "Activation Force and Travel Effects on Overexertion in Repetitive Key Tapping," *Human Factors*, 39(1):130-140 (Mar. 1997).

Rekimoto "SmartSkin: An Infrastructure for Freehand Manipulation on Interactive Surfaces" CHI 2002, Apr. 20-25, 2002.

Rekimoto et al., "ToolStone: Effective Use of the Physical Manipulation Vocabularies of Input Devices," In Proc. of UIST 2000, 2000.

Rubble et al., "Programmable Finger-Tracking Instrument Controllers," *Computer Music Journal*, vol. 14, No. 1 (Spring 1990).

Rutledge et al., "Force-To-Motion Functions for Pointing," Human-Computer Interaction—INTERACT (1990).

Subatai Ahmad, "A Usable Real-Time 3D Hand Tracker," Proceedings of the 28th Conference on Signals, Systems and Computers—Part 2 (of2), vol. 2 (Oct. 1994).

Texas Instruments "TSC2003 / I2C Touch Screen Controller" Data Sheet SBAS 162, dated Oct. 2001, 20-pgs.

Wellner, "The Digital Desk Calculators: Tangible Manipulation on a Desk Top Display" IN ACM UIST '91 Proceedings, pp. 27-34, Nov. 1991.

Williams, "Applications for a Switched-Capacitor Instrumentation Building Block" Linear Technology Application Note 3, Jul. 1985, pp. 1-16.

Yamada et al., "A Switched-Capacitor Interface for Capacitive Pressure Sensors" IEEE Transactions on Instrumentation and Measurement, vol. 41, No. 1, Feb. 1992, pp. 81-86.

Yeh et al., "Switched Capacitor Interface Circuit for Capacitive Transducers" 1985 IEEE.

Zhai et al., "Dual Stream Input for Pointing and Scrolling," *Proceedings of CHI '97 Extended Abstracts* (1997).

Zimmerman et al., "Applying Electric Field Sensing to Human-Computer Interfaces," In CHI '85 Proceedings, pp. 280-287, 1995.

U.S. Appl. No. 10/774,053, filed Feb. 5, 2004.

U.S. Appl. No. 11/140,529, filed May 27, 2005 which is a Reissue of 6,570,557.

U.S. Appl. No. 11/381,313, filed May 2, 2006 entitled "Multipoint Touch Surface Controller".

U.S. Appl. No. 11/332,861, filed Jan. 13, 2006 which is a Reissue of 6,677,932.

U.S. Appl. No. 11/380,109, filed Apr. 25, 2006 entitled "Keystroke Tactility Arrangement on Smooth Touch Surface."

U.S. Appl. No. 11/428,501, filed Jul. 3, 2006 entitled "Capacitive Sensing Arrangement," which is a Continuation of US 20050104867.

U.S. Appl. No. 11/428,503, filed Jul. 3, 2006 entitled "Touch Surface" which is a Continuation of US 2005/0104867.

U.S. Appl. No. 11/428,506, filed Jul. 3, 2006 entitled "User Interface Gestures" which is a Continuation of US 2005/0104867.

U.S. Appl. No. 11/428,515, filed Jul. 3, 2006 entitled "User Interface Gestures" which is a Continuation of US 2005/0104867.

U.S. Appl. No. 11/428,522, filed Jul. 3, 2006 entitled "Identifying Contacts on a Touch Surface" which is a Continuation of US 2005/0104867.

(56) **References Cited**

OTHER PUBLICATIONS

U.S. Appl. No. 11/428,521, filed Jul. 3, 2006 entitled "Identifying Contacts on a Touch Surface" which is a Continuation of US 2005/0104867.

U.S. Appl. No. 11/426,078, filed Jun. 23, 2006 entitled "Electronic Device Having Display and Surrounding Touch Sensitive Bezel for User Interface and Control" which is a Continuation-in-Part of 2006/0197753.

U.S. Appl. No. 11/278,080, filed Mar. 30, 2006 entitled "Force Imaging Input Device and System".

U.S. Appl. No. 11/382,402, filed May 9, 2006 entitled "Force and Location Sensitive Display" which is a Continuation of U.S. Appl. No. 11/278,080.

International Search Report received in corresponding PCT application No. PCT/US2006/008349 dated Oct. 6, 2006.

* cited by examiner

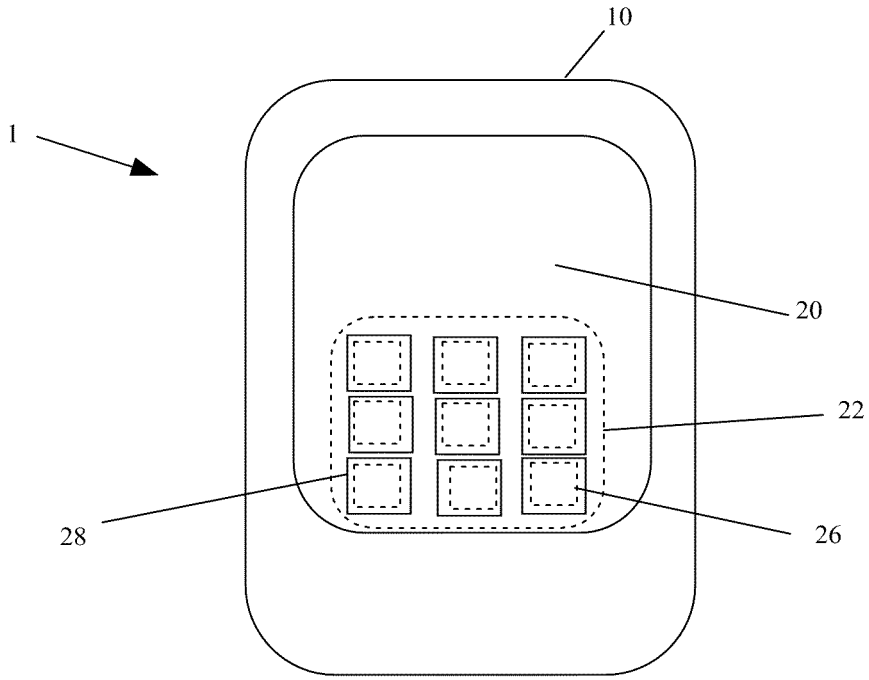


FIG. 1A

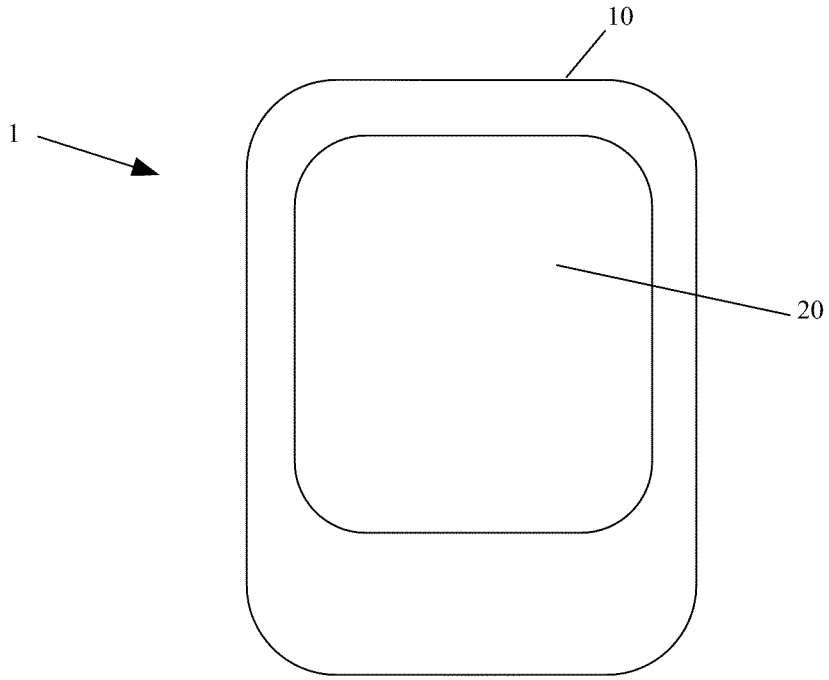


FIG. 1B

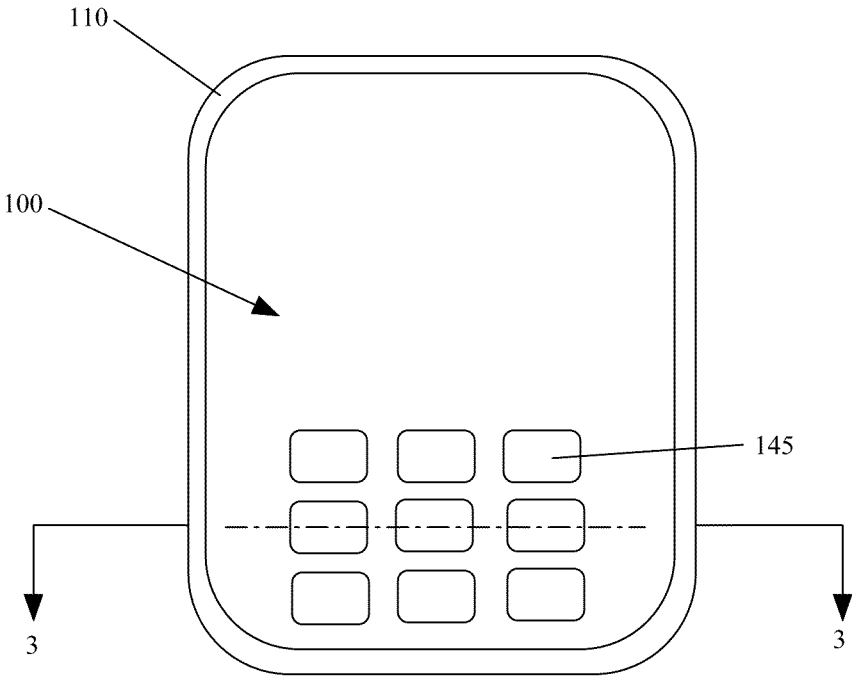


FIG. 2

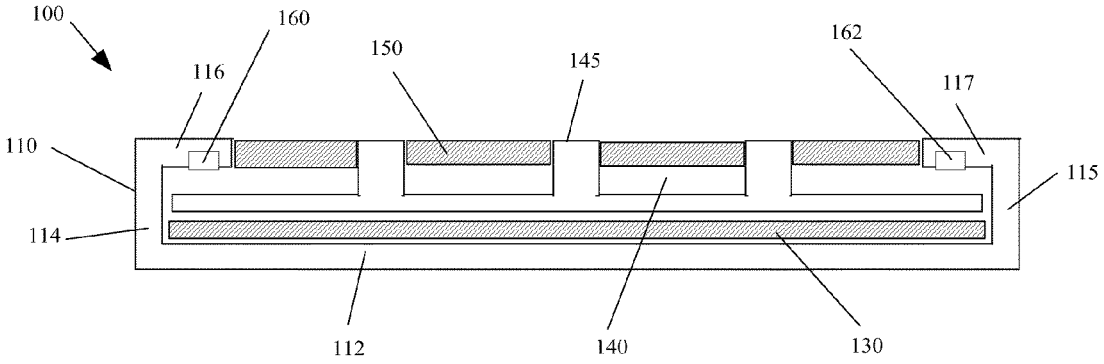

100
160
116
150
145
162
117
110
115
114
112
140
130

FIG. 3A

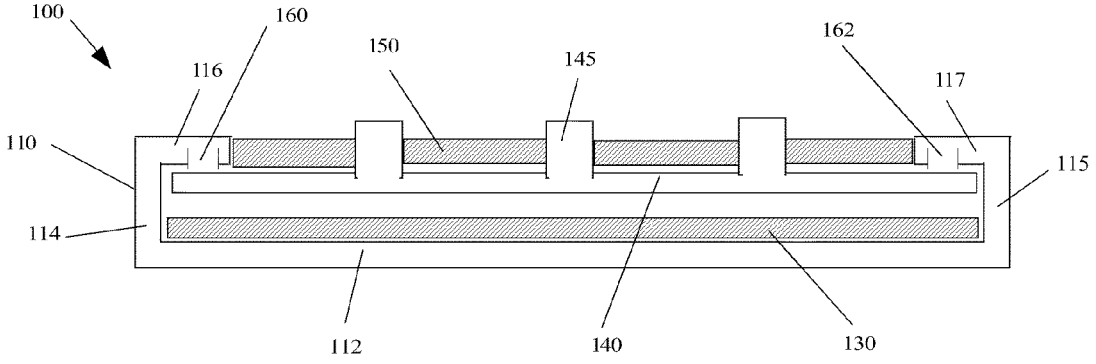

100
160
116
150
145
162
117
110
115
114
112
140
130

FIG. 3B

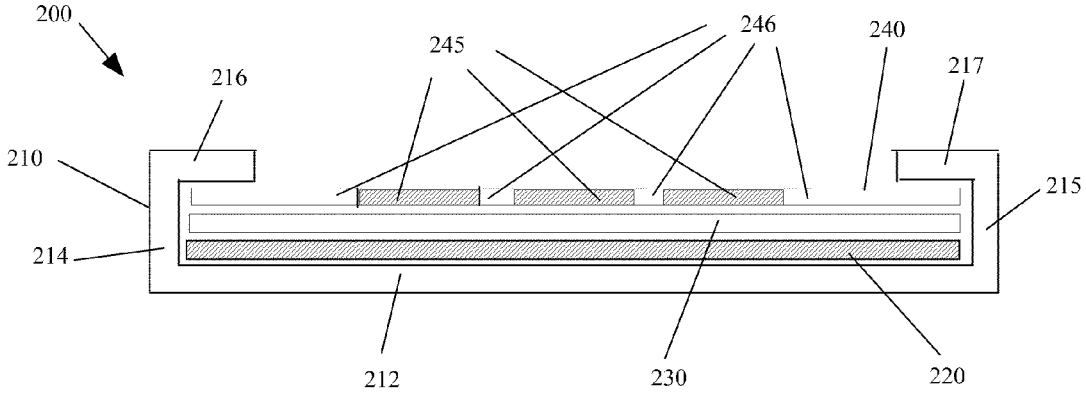

200
216
245
246
240
217
210
215
214
212
230
220

FIG. 4A

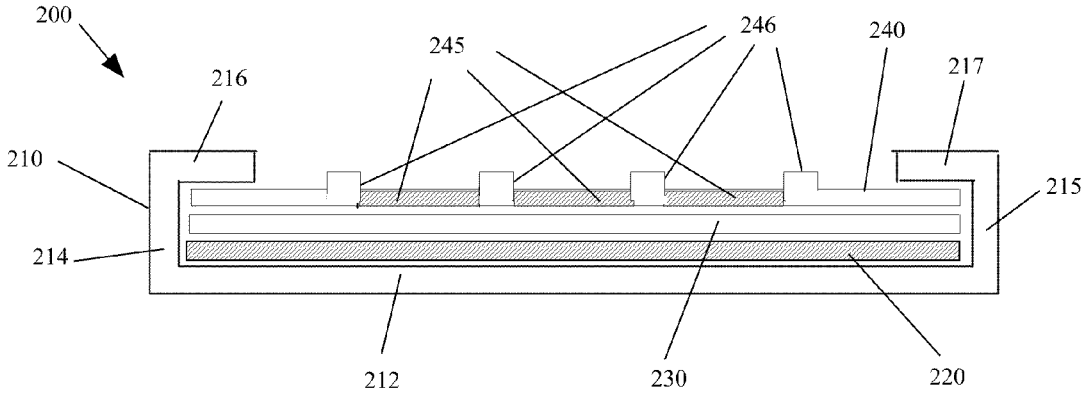

200
216
245
246
240
217
210
215
214
212
230
220

FIG. 4B

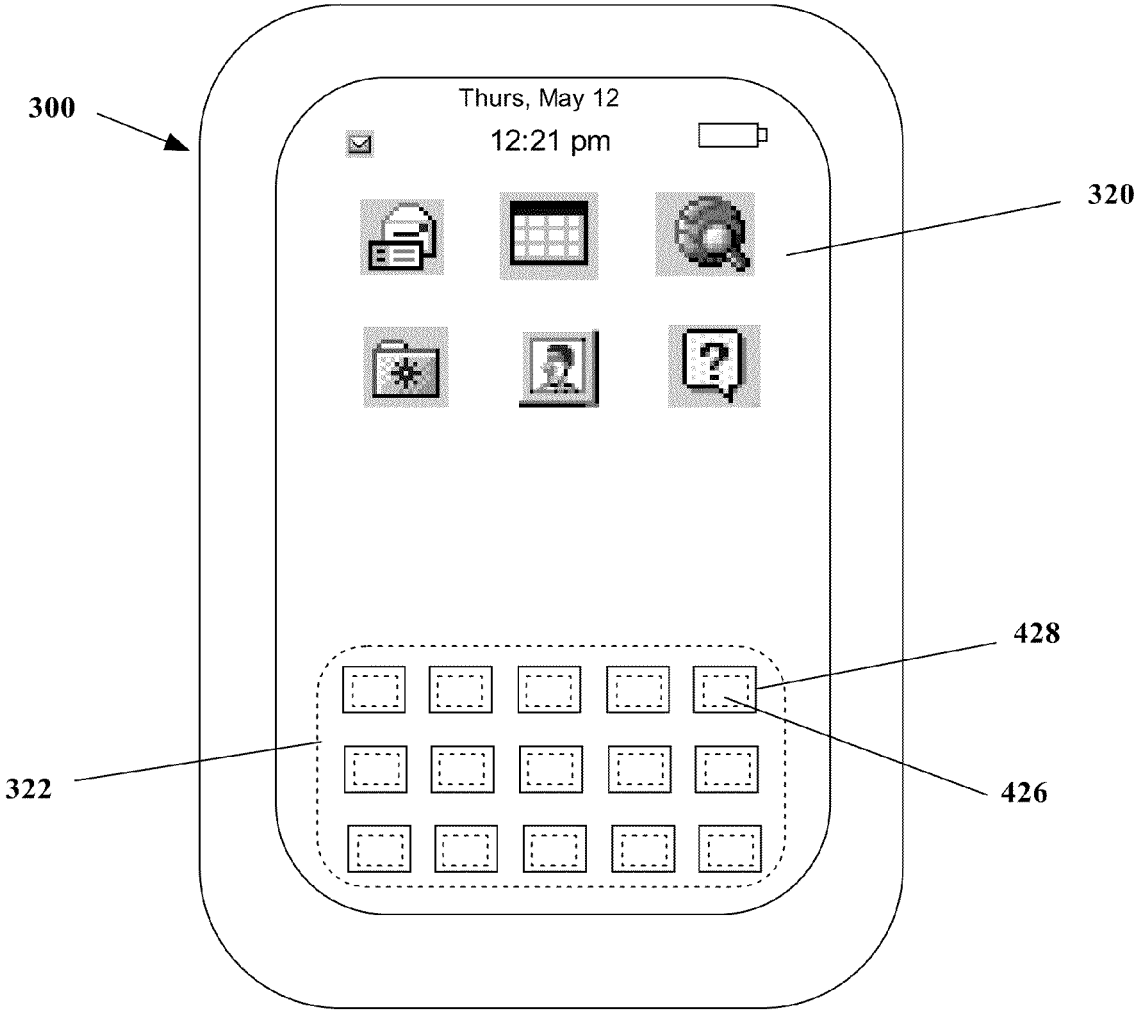


FIG. 5

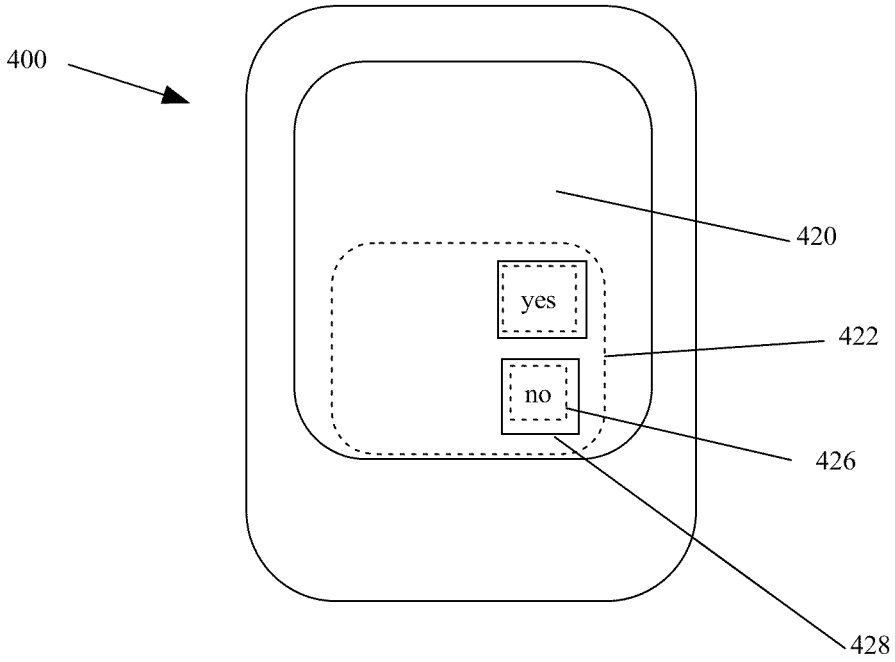

400
420
yes
422
no
426
428

FIG. 6A

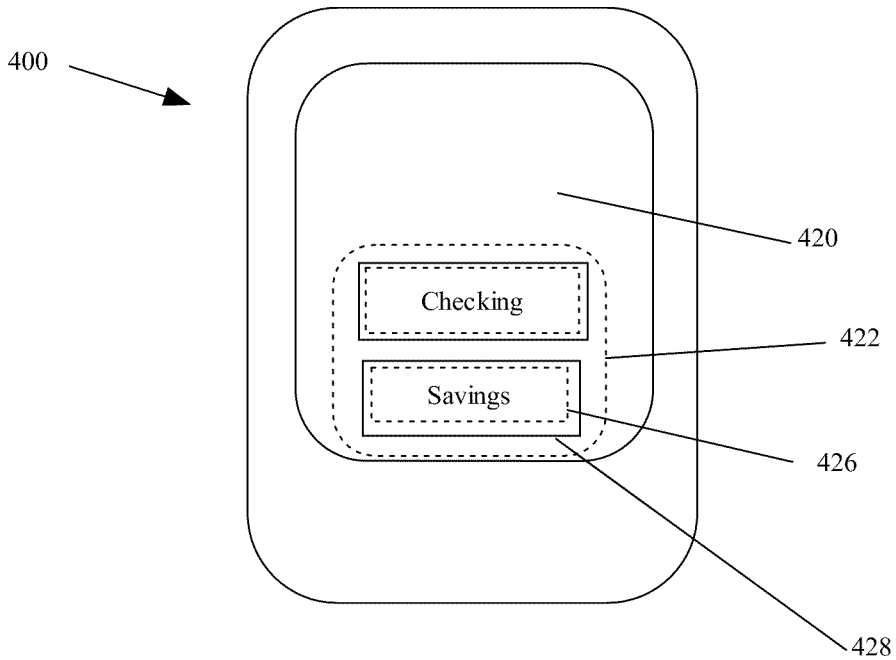

400
420
Checking
422
Savings
426
428

FIG. 6B

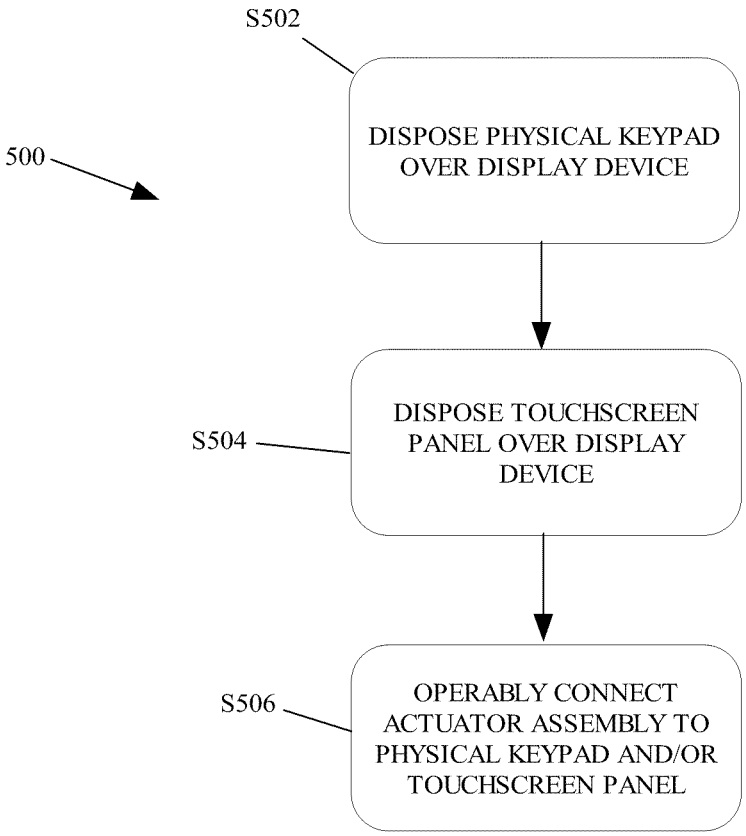

S502
500
DISPOSE PHYSICAL KEYPAD OVER DISPLAY DEVICE
S504
DISPOSE TOUCHSCREEN PANEL OVER DISPLAY DEVICE
S506
OPERABLY CONNECT ACTUATOR ASSEMBLY TO PHYSICAL KEYPAD AND/OR TOUCHSCREEN PANEL

FIG. 7

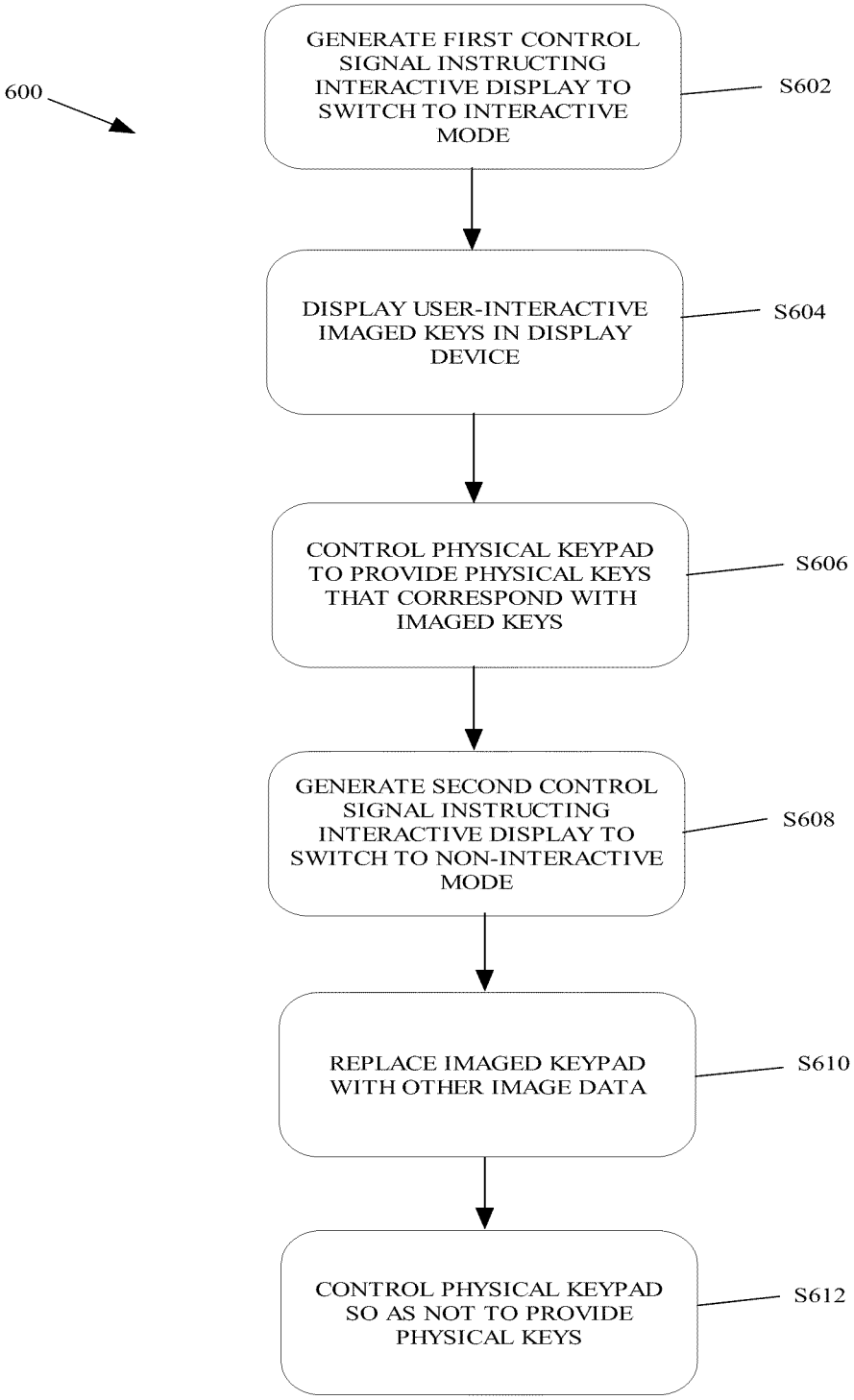

600
GENERATE FIRST CONTROL SIGNAL INSTRUCTING INTERACTIVE DISPLAY TO SWITCH TO INTERACTIVE MODE
S602
DISPLAY USER-INTERACTIVE IMAGED KEYS IN DISPLAY DEVICE
S604
CONTROL PHYSICAL KEYPAD TO PROVIDE PHYSICAL KEYS THAT CORRESPOND WITH IMAGED KEYS
S606
GENERATE SECOND CONTROL SIGNAL INSTRUCTING INTERACTIVE DISPLAY TO SWITCH TO NON-INTERACTIVE MODE
S608
REPLACE IMAGED KEYPAD WITH OTHER IMAGE DATA
S610
CONTROL PHYSICAL KEYPAD SO AS NOT TO PROVIDE PHYSICAL KEYS
S612

FIG. 8

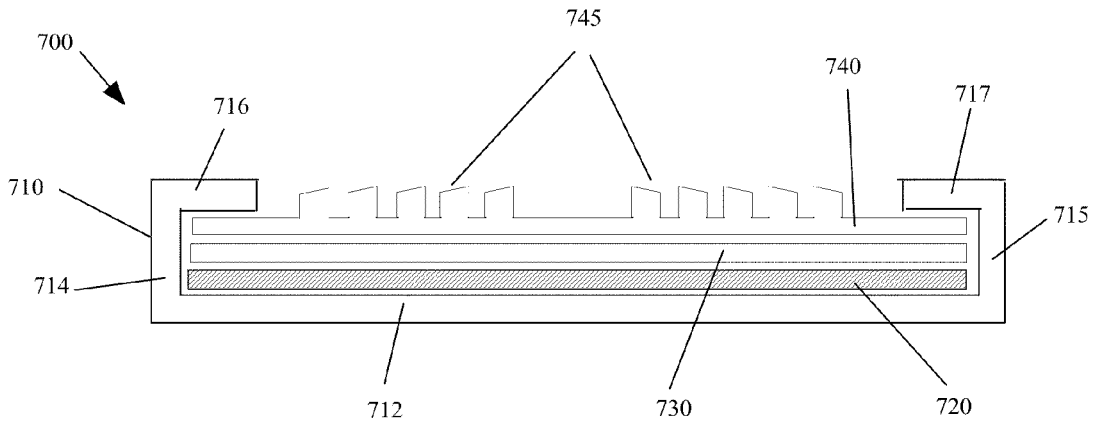

700
745
740
717
716
710
715
714
712
730
720

FIG. 9

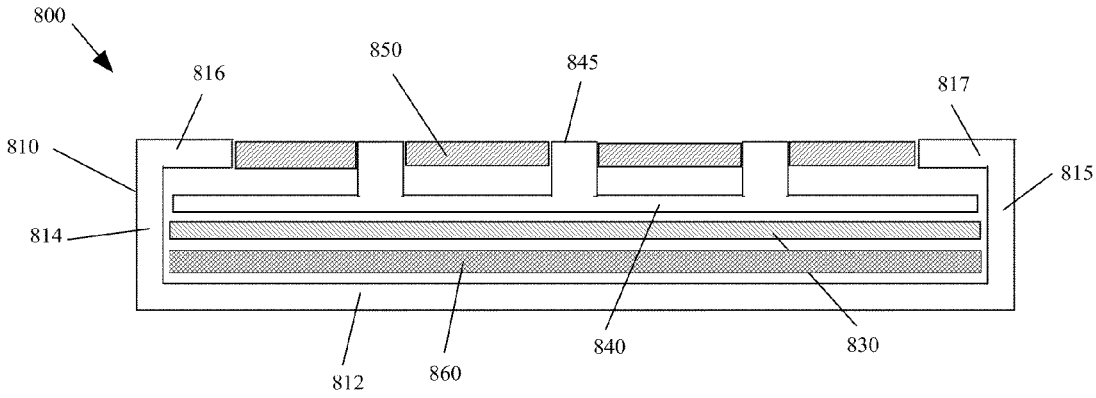

800
850
845
816
817
810
815
814
840
830
812
860

FIG. 10

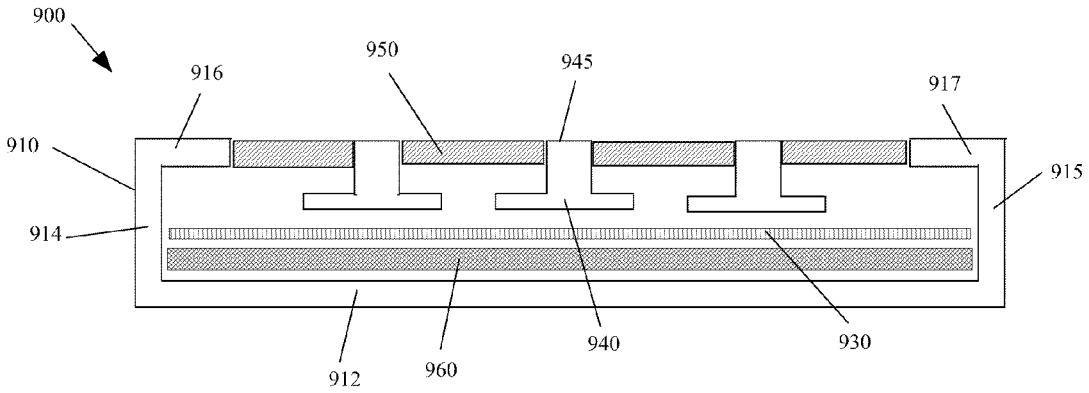


FIG. 11

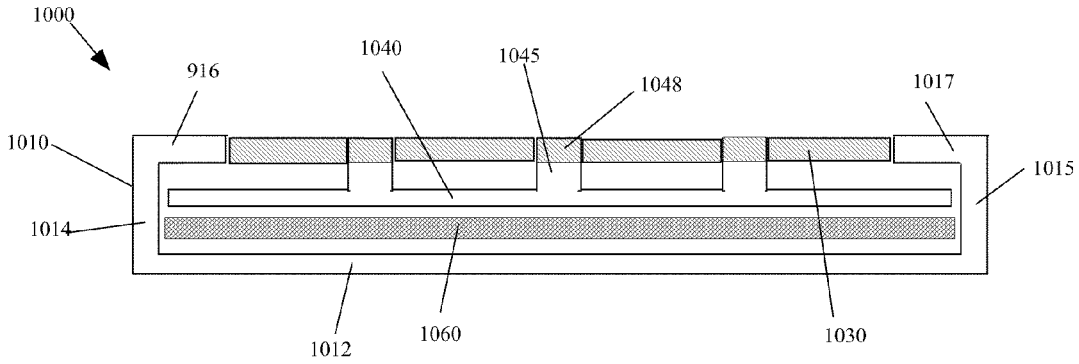


FIG. 12A

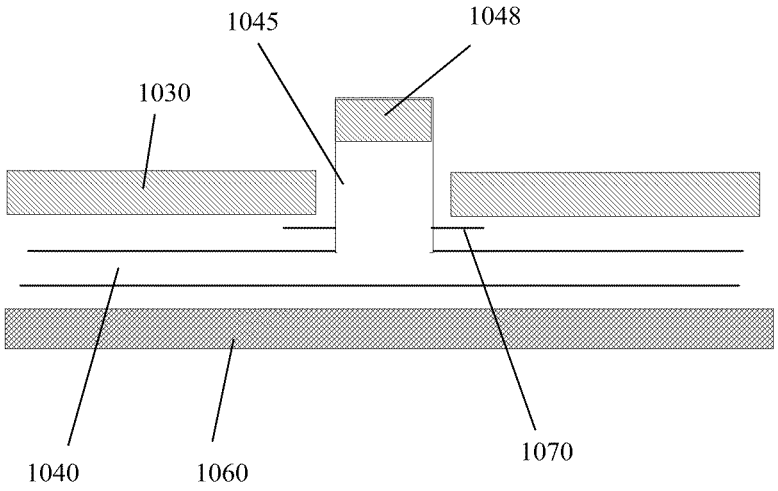


FIG. 12B

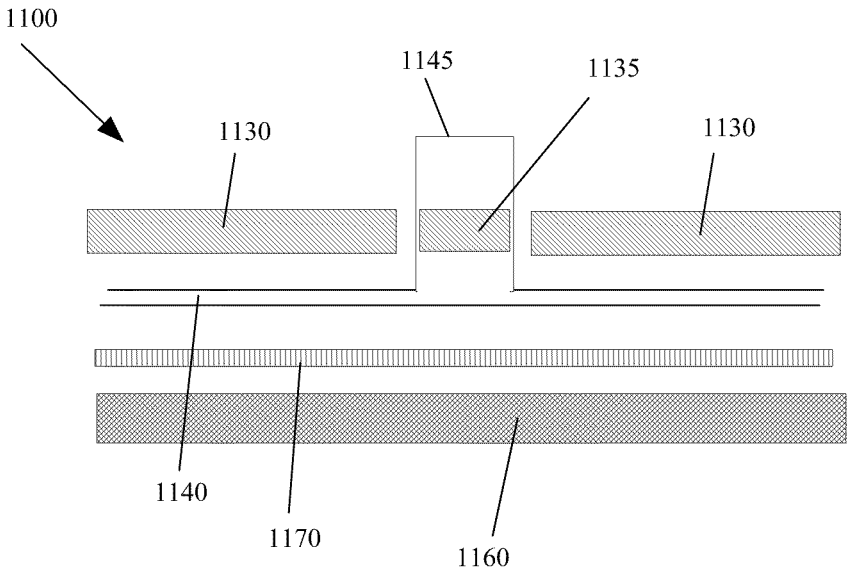


FIG. 13

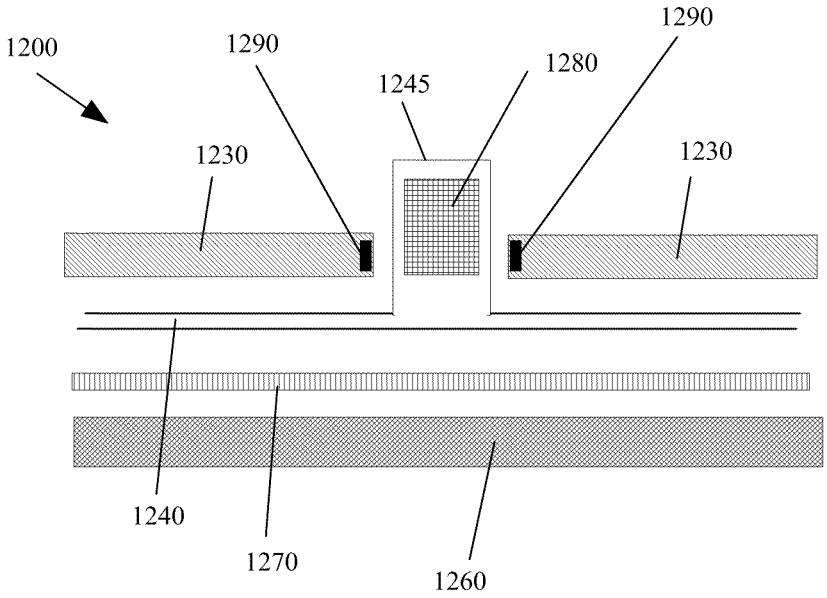


FIG. 14

APPARATUS AND METHOD FOR INTERACTIVE DISPLAY WITH TACTILE FEEDBACK

RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 12/339,721, entitled Apparatus and Method for Interactive Display With Tactile Feedback, filed Dec. 19, 2008, which is a continuation-in-part of U.S. patent application Ser. No. 12/142,624, entitled Apparatus and Method for Interactive Display With Tactile Feedback, filed Jun. 19, 2008, the contents of which are incorporated herein by reference in their entirety.

FIELD OF THE INVENTION

The present invention relates to interactive displays for electronic devices, and in particular to an interactive display that provide tactile feedback to a user when the user applies pressure to the interactive display.

SUMMARY OF THE INVENTION

An electronic device comprising: an interactive display having a first mode and a second mode, the interactive display comprising: an image display device that displays a first user-interactive imaged keypad when the interactive display is in the first mode, and that displays a second user-interactive imaged keypad when the interactive display is in the second mode; and a substantially transparent keypad comprising physical keys permanently formed within the display so that the substantially transparent keypad provides tactile feedback to a user indicating location of keys within the first and second imaged keypads.

In at least one embodiment, the interactive display further has a third mode, wherein the image display is not interactive in the third mode.

In at least one embodiment, a touch screen display element is disposed within each key of the first and second imaged keypads.

In at least one embodiment, the electronic device is selected from one of the following: a personal digital assistant, a cell phone, an automated teller machine, a computer, a gaming device, a television monitor, video conferencing equipment, and a hand-held mobile device.

In at least one embodiment, the physical keys permanently formed within the display comprise one or more of the following: bumps, ridges, indented regions, and other physical alteration of the substantially transparent keypad.

An electronic device according to an exemplary embodiment of the present invention comprises: an interactive display having an interactive mode and a non-interactive mode, the interactive display comprising: an image display device that displays a user-interactive imaged keypad in at least a portion of the image display device when the interactive display is in the interactive mode and that displays other image data in the at least a portion of the image display device when the interactive display is in the non-interactive mode; and a substantially transparent physical keypad that provides tactile feedback to a user indicating location of one or more imaged keys within the imaged keypad in response to one or more actuators disposed below the image display device.

In at least one embodiment, the image display device is structured so as to form a seal for the electronic device.

In at least one embodiment, the physical keypad comprises one or more physical keys corresponding to the imaged keys.

In at least one embodiment, the image display device and the physical keypad are integral to one another.

In at least one embodiment, the one or more physical keys are made of substantially transparent material so that the imaged keys may be viewed within the one or more physical keys.

In at least one embodiment, the imaged keypad comprises one or more sub-keypads, each of the one or more sub-keypads being selectively activated.

In at least one embodiment, one or more portions of the physical keypad are selectively activated to correspond to the one or more sub-keypads.

In at least one embodiment, the physical keypad provides tactile feedback only when the interactive display is in the interactive mode.

In at least one embodiment, the physical keypad comprises piezoelectric material.

In at least one embodiment, the piezoelectric material is quartz.

In at least one embodiment, the physical keypad is made of a magnetostrictive material.

In at least one embodiment, the image display device is selected from one of the following types of image display devices: liquid crystal displays, digital light processor displays, plasma displays and light emitting diode displays.

In at least one embodiment, the image display device is a touchscreen image display device.

In at least one embodiment, the physical keypad comprises physical keys that extend through corresponding openings in the touchscreen image display device.

In at least one embodiment, the one or more actuators move at least one of the physical keypad and the touchscreen display device relative to one another so that the one or more physical keys protrude through the openings in the touchscreen display device when the interactive display is in the interactive mode.

In at least one embodiment, one or more of the physical keys each comprise one or more magnetic elements.

In at least one embodiment, the touchscreen display device comprises one or more charged electrical circuit elements so that movement of the one or more physical keys comprising the one or more magnetic elements relative to the charged electrical circuits elements generate electricity.

In at least one embodiment, the electronic device further comprises a protective layer disposed between the physical keypad and the at least one magnetic actuator to prevent damage to the magnetic actuator resulting from contact with the physical keys.

In at least one embodiment, the electronic device is selected from one of the following types of electronic devices: cell phones, personal digital assistants, automatic teller machines and data input devices.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and related objects, features and advantages of the present invention will be more fully understood by reference to the following, detailed description of the preferred, albeit illustrative, embodiment of the present invention when taken in conjunction with the accompanying figures, wherein:

FIGS. **1**A and **1**B are front views of an electronic device according to an exemplary embodiment of the present invention;

FIG. **2** is a plan view of an interactive display according to an exemplary embodiment of the present invention;

FIGS. **3**A and **3**B are cross-sectional views of an interactive display according to an exemplary embodiment of the present invention;

FIGS. **4**A and **4**B are cross-sectional views of an interactive display according to another exemplary embodiment of the present invention;

FIG. **5** is a plan view of an electronic device according to an exemplary embodiment of the present invention;

FIGS. **6**A and **6**B are plan views of an electronic device according to another exemplary embodiment of the present invention;

FIG. **7** is a flowchart showing a method of manufacturing an interactive display according to an exemplary embodiment of the present invention;

FIG. **8** is a flowchart showing a method of operation of an interactive display according to an exemplary embodiment of the present invention;

FIG. **9** is a cross-sectional view of an interactive display according to an exemplary embodiment of the present invention

FIG. **10** is a cross-sectional view of an interactive display according to an exemplary embodiment of the present invention;

FIG. **11** is a cross-sectional view of an interactive display according to an exemplary embodiment of the present invention;

FIG. **12**A is a cross-sectional view of an interactive display according to an exemplary embodiment of the present invention;

FIG. **12**B is a detailed cross-sectional view of a section of the interactive display shown in FIG. **12**A;

FIG. **13** is a cross-sectional view of an interactive display according to an exemplary embodiment of the present invention; and

FIG. **14** is a cross-sectional view of an interactive display according to an exemplary embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

The present invention is directed to an electronic device including an interactive display having an interactive mode in which a user-interactive keypad is displayed in at least a portion of the interactive display and a non-interactive mode in which other image data is displayed in the portion of the interactive display. The interactive display includes a substantially transparent keypad portion that provides tactile feedback to allow the user to locate individual keys within the keypad portion. The present invention is applicable to any electronic device having a touchscreen display, including, for example, personal digital assistants (PDAs), cell phones, automated teller machines (ATMs), computers (including laptop and desktop computers), gaming devices, television monitors, video conferencing equipment and any general data input device.

FIGS. **1**A and **1**B are front views of an electronic device, generally designated by reference number **1**, according to an exemplary embodiment of the present invention. In the present embodiment, the electronic device **1** may be, for example, a PDA, cell phone, or other hand-held mobile device. The electronic device **1** includes a housing **10** and an interactive display **20**. The housing **10** protects the internal electronic components of the electronic device **1**, and clips or other similar elements may be disposed on the outside of the housing **10** to allow the electronic device to be attached to an object.

In FIG. **1**A, the electronic device **1** is in an interactive mode. In this mode, an interactive keypad **22** is displayed within a portion of the interactive display **20**. The interactive keypad **22** includes one or more imaged keys **26**. Each imaged key **26** may be "pressed" by a user to input data to the electronic device **1** by applying physical pressure to the interactive display **20** over the imaged key **26**. Such "touchscreen" technology is well known in the art, such as in U.S. Pat. Nos. 5,815,141, 6,297,811, and 5,784,054, the contents of which are incorporated herein by reference. One or more other images may be displayed in other portions of the interactive display **20**. Also, in the interactive mode, the interactive display **20** includes physical keys **28**, such as, for example, bumps, ridges, indented regions or any other type of physical alteration that provides tactile feedback to a user, that correspond with the imaged keys **26** within the interactive keypad **22**.

In FIG. **1**B, the electronic device **1** is in a non-interactive mode. In this mode, the interactive keypad **22** is not displayed within the interactive display **20** and one or more other images may fully occupy the interactive display **20**. Also, in the non-interactive mode, the interactive display **20** may be automatically modified so as not to include the physical keys **28** (i.e., the interactive display **20** may be completely smooth). Alternatively, the physical keys **28** may be formed permanently within the interactive display **20**. A switch (not shown) may be provided through the housing **10** to allow a user to alternate the electronic device **1** between the interactive mode and the non-interactive mode.

FIG. **2** is a plan view of an interactive display, generally designated by reference number **100**, according to an exemplary embodiment of the present invention. The interactive display **100** is shown held within a frame element **110**. The interactive display may include one or more physical keys **145**. As explained in further detail below, the top surface of the physical keys **145** may be level with the top plane of the interactive display **100** when the interactive display **100** is in the non-interactive mode, and the top surface of the keys **145** may be moved outside the top plane of the interactive display **100** when the interactive display **100** is in the interactive mode so that bumps or protrusions are formed in the interactive display **100** that correspond with displayed imaged keys.

FIGS. **3**A and **3**B are cross-sectional views of the interactive display **100** taken along line **3**-**3** in FIG. **2**. In FIG. **3**A, the interactive display **100** is in the non-interactive mode, and in the FIG. **3**B, the interactive display **100** is in the interactive mode. As shown in FIGS. **3**A and **3**B, the frame element **110** may include a bottom wall **112**, side walls **114**, **115** and top walls **116**, **117**. The interactive display **100** may be housed within the frame element **110** with the bottom surface of the interactive display **100** resting on the bottom wall **112** of the frame element **110**. The interactive display **100** may include a display device **130**, a physical keypad **140** including the physical keys **145** disposed over the display device **130**, and a touchscreen panel **150** disposed over the physical keypad **140**.

The display device **130** may be any suitable display device, such as, for example, a liquid crystal display (LCD), a digital light processing (DLP) display, a plasma display or a light-emitting diode (LED) display, to name a few. As is known in the art, the display device **130** may include programmable elements that emit and/or block light to generate images. In the present embodiment, the display device **130** may display an imaged keyboard when the interactive display **100** is in the interactive mode.

The physical keypad **140** is a generally flat sheet or plate. The physical keys **145** are formed on the top surface of the

physical keypad **140**, and extend upwards towards the touchscreen panel **150**. The physical keypad **140** is preferably made of a transparent material, such as, for example, plastic or glass. Any number of physical keys **145** may be formed on the physical keypad **140**. In an exemplary embodiment, the number and shape of the physical keys **145** are made to correspond to the number and shape of the imaged keys in the imaged keyboard displayed by the display device **130**.

The touchscreen panel **150** may be a transparent panel that generates a programming signal when pressure is applied to one or more areas on the touchscreen panel **150**. Various programming signals generated by the touchscreen panel **150** may be sent to the display device **130**, resulting in formation or manipulation of images in the display device **130**. For example, a user may apply pressure to the touchscreen panel **150** to activate the imaged keyboard and place the interactive display **100** in the interactive mode. Any suitable touchscreen technology may be used for the touchscreen panel **150**, such as, for example, resistive touchscreens, surface acoustic wave touchscreens, capacitive touchscreens, infrared touchscreens, strain gauge touchscreens, optical imaging, dispersive signal technology, acoustic pulse recognition, total internal reflection, and diffused laser imaging, to name a few.

The touchscreen panel **150** may include a number of openings **152** that correspond with the physical keys **145** of the physical keypad **140**. The physical keys **145** extend through the openings **152**. When the interactive display **100** is in the non-interactive mode, the top surfaces of the physical keys **145** may be co-planar with the top surface of the touchscreen panel **150**. When the interactive display **100** is in the interactive mode, the top surfaces of the physical keys **145** may be raised or lowered relative to the top surface of the touchscreen panel **150**, so that the touchscreen panel **150** includes a number of protrusions or indentations that correspond to the imaged keys in the imaged keypad. Thus, when the interactive display **100** is in the interactive mode, a user is able to feel the location of the various imaged keys based on the tactile feedback provided by the protrusions or indentations in the touchscreen panel **150**.

In an exemplary embodiment of the present invention, first and second actuators **160**, **162**, located on either side of the frame element **110**, may be used to manipulate the physical keypad **140** and thereby raise and lower the physical keys **145** relative to the touchscreen panel **150**. The first and second actuators **160**, **162** may be any suitable actuators, such as, for example, mechanical actuators, such as springs, microelectromechanical devices (MEMS), piezoelectric actuators and magnetostrictive actuators, to name a few. It should be appreciated that the number of actuators is not limited to two, and any number of actuators located at any suitable position relative to the physical keypad **140** may be used to raise and lower the physical keypad **140**. Alternatively, the actuators **160**, **162** may be used to raise and lower the touchscreen panel **150** rather than the physical keypad **140**.

FIGS. **4**A and **4**B are cross sectional views of an interactive display, generally designated by reference number **200**, according to another exemplary embodiment of the present invention. In FIG. **4**A, the interactive display **200** is in the non-interactive mode, and in the FIG. **4**B, the interactive display **200** is in the interactive mode. As in the previous embodiment, the interactive display **200** may be housed within a frame element **210** including a bottom wall **212**, side walls **214**, **215** and top walls **216**, **217**. The interactive display **200** may includes a display device **220**, a touchscreen panel **230** disposed over the display device **220**, and a physical keypad **240** disposed over the touchscreen panel **230**. As in the previous embodiment, the display device **220** may be, for example, an LCD display, a DLP display, a plasma display or a LED display. The touchscreen panel **230** may use any of the touchscreen technology as described regarding the previous embodiment.

The physical keypad **240** in the present embodiment may include physical keys **245** defined by a material that changes shape under the influence of an electric or magnetic field. For example, the physical keys **245** may be made of a piezoelectric material, such as, for example, quartz, or a magnetostrictive material, such as, for example, ferromagnetic thin films. In the embodiment shown in FIGS. **4**A and **4**B, the physical keys **245** are defined by a grid structure **246** of piezoelectric material formed within the physical keypad **240**. Thus, the grid structure **246** may either deflect downwards or upwards under the application of an electric field, thereby forming protrusions or indentations around the physical keys **245**. In the embodiment shown in FIG. **4**B, the grid structure **246** is structured so as to deflect upwards when an electric field is applied, thereby forming protrusions that define the physical keys **245**. Thus, in the interactive mode, the user is able to feel the location of the physical keys **245**. Deformation of the physical keys **245** in this embodiment may also result in generation of electricity, which may be fed back to the interactive display **200** as a power source.

It should be appreciated that the present invention is not limited to the above described embodiments. For example, in other exemplary embodiments, each physical key may be made of two or more pieces of transparent material that are made to deflect relative to one another when the interactive display is switched between the interactive and non-interactive modes so as to form appropriate protrusions or indentations in the interactive display that demark the physical keys. In such an embodiment, an additional transparent layer may be disposed over the physical keypad, so that when the two or more pieces of material that form the physical keys are deflected, smooth bumps or indentations are formed in the transparent layer.

Further, as shown in FIGS. **5** and **6**A-B, the interactive display of the present invention may include any number and shape of imaged and physical keys. In particular, in the embodiment shown in FIG. **5**, an electronic device **300**, such as a personal digital assistant, may include an interactive display **320** that provides a full keypad **322**, including physical keys **328** corresponding with imaged keys **326**, when in the interactive mode. In the embodiment shown in FIGS. **6**A and **6**B, an electronic device **400**, such as an ATM, may include an interactive display **420** that provides a partial keypad **422**, including physical keys **428** corresponding with imaged keys **426**, when in the interactive mode. In the case of ATMs, the imaged keys **426** may be displayed in various shapes. For example, as shown in FIG. **6**A, the electronic device **400** may display imaged keys **426** that are generally square shaped, while in FIG. **6**B the electronic device **400** may display imaged keys **426** that are generally rectangular shaped. The physical keys **428** of the electronic device **400** may be made to mirror the different shapes of the imaged keys **426**. In this regard, controlled magnetic and/or electric fields may be delivered to the physical keypad of the electronic device **400** to result in the appropriately shaped physical key **428**.

In other exemplary embodiments of the present invention, the interactive display may include separate regions, where one or more regions are interactive and one or more other regions are not interactive. Further, the interactive display may be composed of more than one display, where one or more of the displays are interactive and one or more other displays are not interactive.

FIG. **7** is a flowchart showing a method, generally designated by reference number **500**, of manufacturing an interactive display according to an exemplary embodiment of the present invention. In the present method, various layers of the interactive display may be disposed over one another and adhered to one another to provide a unitary structure. For example, one or more of the various layers may be laminated to one another. In step S**502**, a physical keypad having physical keys is disposed over a display device. The display device may be any suitable display device, such as, for example, an LCD display, a DLP display or a LED display, to name a few. The physical keypad may include, for example, permanent physical keys or be constructed of material that results in generation of temporary physical keys upon application of an electric or magnetic field to the physical keypad. In step S**504**, a touchscreen panel is disposed over the display device. The touchscreen panel may have one or more openings through which physical keys of the physical keypad may protrude. In step S**506** an actuator assembly is operably attached to the physical keypad and/or the touchscreen panel. The actuator assembly may be controlled to deliver an appropriate magnetic or electric field to the physical keypad so as to generate temporary physical keys. Alternatively, the physical keypad and the touchscreen panel may be movable relative to one another through control of the actuator assembly, in which case the actuator assembly may include any suitable actuator that provides translation forces, such as, for example, springs, MEMS devices, and piezoelectric actuators, to name a few.

FIG. **8** is a flowchart showing a method of operation, generally designated by reference number **600**, of an interactive display according to an exemplary embodiment of the present invention. In step S**602**, the interactive display generates a first control signal instructing the interactive display to switch into an interactive mode. In step S**604**, based on the second control signal, a display device of the interactive display displays user-interactive imaged keys of an imaged keypad. In step S**606**, based on the first control signal, a physical keypad of the interactive display is controlled to provide physical keys that correspond with the imaged keys of the imaged keypad. In step S**608**, the interactive display generates a second control signal instructing the interactive display to switch into a non-interactive mode. In step S**610**, based on the second control signal, the display device replaces the imaged keypad with other image data. In step S**612**, based on the second control signal, the physical keypad of the interactive display is controlled so as not to provide physical keys.

FIG. **9** is a cross sectional views of an interactive display, generally designated by reference number **700**, according to another exemplary embodiment of the present invention. As in the previous embodiment, the interactive display **700** may be housed within a frame element **710** including a bottom wall **712**, side walls **714**, **715** and top walls **716**, **717**. The interactive display **700** may includes a display device **720**, a touchscreen panel **730** disposed over the display device **720**, and a physical keypad **740** disposed over the touchscreen panel **730**. As in the previous embodiment, the display device **720** may be, for example, an LCD display, a DLP display, a plasma display or a LED display. The touchscreen panel **730** may use any of the touchscreen technology as described regarding the previous embodiment.

The physical keypad **740** in the present embodiment may include physical keys **245**. The physical keys **745** are preferably transparent and may be integrally formed with the remaining portions of the physical keypad **740** by a molding operation. In the exemplary embodiment shown in FIG. **9**, the physical keys **245** protrude outwards away from the display device **720**. However, in other exemplary embodiments, the physical keys **245** may protrude inwards towards the display device **720**.

As shown in FIG. **9**, the physical keys **745** on the right side of the physical keypad **740** may include top surfaces that are inclined towards the right, and the physical keys **745** on the left side of the physical keypad **740** may include top surfaces that are inclined towards the left. This arrangement prevents a user's finger from sliding off a physical key **745** onto an adjacent physical key **745**. There may also be additional space provided between the left side physical keys **745** and right side physical keys **745** to allow for better viewing of the image when the interactive display **700** is in the non-interactive mode.

FIG. **10** is a cross sectional views of an interactive display, generally designated by reference number **800**, according to another exemplary embodiment of the present invention. As in the previous embodiments, the interactive display **800** may be housed within a frame element **810** including a bottom wall **812**, side walls **814**, **815** and top walls **816**, **817**. The interactive display **800** may includes a display device **830**, a physical keypad **840** disposed over the display device **830**, and a touchscreen panel **850** disposed over the physical keypad **840**. The physical keys **845** of the physical keypad **840** may protrude through openings in the touchscreen panel **850** when the interactive display **800** is in the interactive mode. As in the previous embodiments, the display device **830** may be, for example, an LCD display, a DLP display, a plasma display or a LED display. The touchscreen panel **850** may use any of the touchscreen technology as described regarding the previous embodiments.

In the present embodiment, an actuator element **860** is disposed below the display device **830**. The actuator element **860** may be any type of suitable actuator, such as, for example, piezoelectric actuators or magnetostrictive actuators. It should be appreciated that the number of actuators is not limited to one, and any number of actuators located at any suitable position relative to the physical keypad **840** may be used to raise and lower the physical keypad **845**. Alternatively, the actuator element **860** may be used to raise and lower the touchscreen panel **850** rather than the physical keypad **840**. The structure of the present embodiment allows the display device **830** to be sealed with the frame element **810** so as to protect the actuator element **860** and other internal components from being damaged.

FIG. **11** is a cross sectional views of an interactive display, generally designated by reference number **900**, according to another exemplary embodiment of the present invention. As in the previous embodiments, the interactive display **900** may be housed within a frame element **910** including a bottom wall **912**, side walls **914**, **915** and top walls **916**, **917**. The interactive display **900** may include an actuator element **960**, a protective layer **930** disposed over the actuator element **960**, one or more sub-keypads **940** disposed over the protective layer **930**, and a touchscreen display device **950** disposed over the sub-keypads **940**. The use of the touchscreen display device **950** eliminates the need for a separate touchscreen panel, as in previous embodiments. The sub-keypads **940** may be individually operated by the actuator element **960**, so that different ones of the physical keys **940** may be made to protrude through openings in the touchscreen display device **950**. Thus, as an example, different physical keys **940** may provide tactile feedback to a user depending on the functional mode of the interactive display **900**. Although each sub-keypad **940** is shown in FIG. **11** having only one physical key **945**, it should be appreciated that each sub-keypad **940** may have any number of physical keys **945**.

The protective layer **930** is disposed between the sub-keypads **940** and the actuator element **960** so as to prevent damage to the actuator element **960** that may otherwise result from contact with the sub-keypads **940**. The protective layer **930** may be made of any suitable protective material that does not interfere with the function of the actuator element **960**, such as, for example, felt, cotton, plastic, insulators, cushioning material, etc. The protective material can even be air in one embodiment.

FIG. **11** is a cross sectional views of an interactive display, generally designated by reference number **1000**, according to another exemplary embodiment of the present invention. As in the previous embodiments, the interactive display **1000** may be housed within a frame element **1010** including a bottom wall **1012**, side walls **1014**, **1015** and top walls **1016**, **1017**. The interactive display **1000** may include an actuator element **1060**, a physical keypad **1040** disposed over the actuator element **1060**, and a touchscreen display device **1030** disposed over the physical keypad **1040**. As in the previous embodiment, the physical keypad **1040** may be made up of separate sub-keypads (not shown). Further, a protective layer (not shown) may be disposed between the physical keypad **1040** and the actuator element **1060**.

In the present embodiment, each key **1045** of the physical keypad **1040** forms part of the touchscreen display device **1030**. In this regard, a touchscreen display element **1048** may be disposed within each key **1045**, so that images, such as corresponding imaged keys, may be displayed on each key **1045** as part of the overall image displayed by the touchscreen display device **1030**.

FIG. **12**B is a detailed cross-sectional view of a section of the interactive display **1000**. As shown in this figure, a connective element **1070** may be disposed at the base of each key **1045** so as to provide for delivery of appropriate signals to the key **1045** to display an image within the corresponding touchscreen display element **1048**.

FIG. **13** is a cross-sectional view of a section of an interactive display, generally designated by reference number **1100**, accordingly to another exemplary embodiment of the present invention. As in previous embodiment, the interactive display **1100** may be disposed within a frame element (not shown). The interactive display **1100** includes an actuator element **1160**, a protective layer **1170** disposed over the actuator element **1160**, a physical keypad **1140** disposed over the protective layer **1170** and a touchscreen display device **1130** disposed over the physical keypad **1140**. A portion **1135** of the touchscreen display device **1130** may be disposed within each key **1145** of the physical keypad **1140**. In this regard, the keys **1145** of the physical keypad **1140** may be substantially transparent, so that the portions **1135** of the touchscreen display device **1130** may be viewed through the top of each key **1145**.

FIG. **14** is a cross-sectional view of a section of an interactive display, generally designated by reference number **1200**, accordingly to another exemplary embodiment of the present invention. As in the previous embodiment, the interactive display **1200** may be disposed within a frame element (not shown). The interactive display **1200** includes an actuator element **1260**, a protective layer **1270** disposed over the actuator element **1260**, a physical keypad **1240** disposed over the protective layer **1270** and a touchscreen display device **1230** disposed over the physical keypad **1240**. A permanent magnet **1280** is disposed within each key **1245** of the keypad **1240**. One or more charged electrical circuit elements **1290** may be disposed within the touchscreen display device **1230** adjacent each key **1245**. Movement of the key **1245**, and hence the permanent magnet **1280**, within a corresponding opening within the touchscreen display device **1230** relative to the charged electrical circuit elements **1290** results in generation of electricity. The generated electricity may be fed back to the interactive display **1200** as a power source.

Now that the preferred embodiments of the present invention have been shown and described in detail, various modifications and improvements thereon will become readily apparent to those skilled in the art. Accordingly, the spirit and scope of the present invention is to be construed broadly and limited only by the appended claims and not by the foregoing specification.

What is claimed is:

1. An electronic device comprising:

an interactive display having a first mode and a second mode, the interactive display comprising:

an image display device comprising a touch screen display that displays a first image comprising a first user-interactive imaged keypad when the interactive display is in the first mode, and that displays a second image comprising a second user-interactive imaged keypad when the interactive display is in the second mode, the first and second images being different from one another;

a substantially transparent physical keypad that provides tactile feedback to a user indicating location of keys within the first and second imaged keypads, the physical keypad comprising physical keys that protrude through corresponding openings in the touch screen display, an element of the touch screen display being disposed within a respective one of the physical keys, the physical keypad being fixed relative to the touch-screen display; and

one or more actuators that move the image display device between a raised position and a lowered position relative to the physical keypad so that the one or more physical keys protrude through the openings in the touchscreen panel when the touchscreen panel is in the lowered position and the interactive display is in one of the first and second modes.

2. The electronic device of claim **1** where the interactive display further has a third mode, wherein the image display is not interactive in the third mode.

3. The electronic device of claim **1**, wherein the electronic device is selected from one of the following: a personal digital assistant, a cell phone, an automated teller machine, a computer, a gaming device, a television monitor, video conferencing equipment, and a hand-held mobile device.

4. The electronic device of claim **1**, wherein the physical keys formed within the image display device comprise one or more of the following: bumps, ridges, indented regions, and other physical alteration of the substantially transparent keypad.

5. The electronic device of claim **1**, wherein top surfaces of the physical keys on one side of the keypad are inclined in a direction that is different from the direction in which top surface of the physical keys on a second side of the keypad are inclined.

* * * * *